

ART. X.—*The Occipital Bones of the Dipnoi.*

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(Communicated by Professor W. E. Agar.)

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In 1897 Bridge made the statement, "The only endochondral bones in *Ceratodus* are the two exoccipitals." K. Furbringer (1904) draws attention to the fact that Bridge separates these bones sharply from all other bones in the *Ceratodus* skull on the grounds that they are endochondral. Goodrich (1909) accepts Bridge's view of the nature of the bone in the words, "The bone described by Huxley as an exoccipital, the only endochondral ossification in the skull of any Dipnoi, appears to represent the first of the occipital neural arches."

That the exoccipital bone of the Dipnoi is the enlarged first neural arch has been shown by K. Furbringer (1904) for *Ceratodus*, and by Agar (1906) for *Lepidosiren* and *Protopterus*. The reasons for considering it to be an endochondral bone do not appear ever to have been definitely stated. As the question is of some importance in deciding the evolutionary status of the Dipnoi, a histological examination of the bone was undertaken at Professor Agar's suggestion. Well preserved *Ceratodus* skulls were kindly provided by Dr. T. L. Bancroft, of Eidsvold, Queensland, and also by the Director of the Queensland Museum. Comparative material was available in the form of larvæ and young of *Lepidosiren*.

Much depends upon the definition of the term endochondral, which appears to be used in different senses. Adopting Goodrich's classification of the types of bone found in Fishes (1909, p. 63), and which corresponds with Gaupp's nomenclature (1906, p. 610), cartilage bone is of two kinds, perichondral and endochondral. In the former, the bone is deposited layer upon layer by osteoblasts lining the inner surface of the perichondrium (which now becomes the periosteum), thus gradually restricting or replacing the cartilage from outside inwards. Endochondral bone, on the other hand, is formed, not in this, but rather in the opposite way. Spaces are eaten out of the cartilage by osteoclasts, and bone is deposited in the interior of the cavities so formed, and spreads outwards.

Examination of sections of the bone in half-grown *Ceratodus* skulls, and of the development of the bone in *Lepidosiren*, gives no evidence of the formation of endochondral bone in the above sense.

In *Ceratodus* the exoccipital bones are imbedded in the side walls of the chondrocranium. Each is a small hollow bone shaped rather

like an hour glass. The anterior end is slightly more expanded than the posterior, and the whole bone is filled with cartilage (even in the adult), with the exception of the narrow constricted region, where it is bone all through. Transverse sections of one of the exoccipitals from a young *Ceratodus* showed that the ossification was taking place in the periosteum, i.e., it was perichondral. No traces of endochondral bone formation could be observed at all, and since the ossification was very nearly as complete as it ever would be, it seems unlikely that it would occur in a later stage.

The general shape of the occipital bones in *Lepidosiren* is very similar to that of *Ceratodus*, but proportionally they are much larger, as they themselves form the lateral walls for the posterior region of the skull, their anterior surfaces only being in contact with the cartilage of the auditory capsule. They are slightly constricted in the middle owing to their being grooved anteriorly by the vagus, and posteriorly by the first spinal nerve. In the adult *Lepidosiren*, the exoccipital "bones" are very nearly completely ossified, only a small plug of cartilage remains at the dorsal end. Examination of transverse sections of the occipital region at different stages of development indicate that the formation of bone begins in the periosteum, and gradually spreads inwards, upwards, and downwards, replacing the cartilage. As in *Ceratodus* no definite signs of endochondral ossification could be found at any stage.

It would appear therefore that there is not sufficient foundation for the statement that the exoccipital bone in *Ceratodus* or other Dipnoi is an endochondral bone. Such mode of ossification does not seem to have evolved yet in the Dipnoi.

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